

ON SOME MOLLUSCAN REMAINS FROM THE OPAL DEPOSITS
(UPPER CRETACEOUS) OF NEW SOUTH WALES.

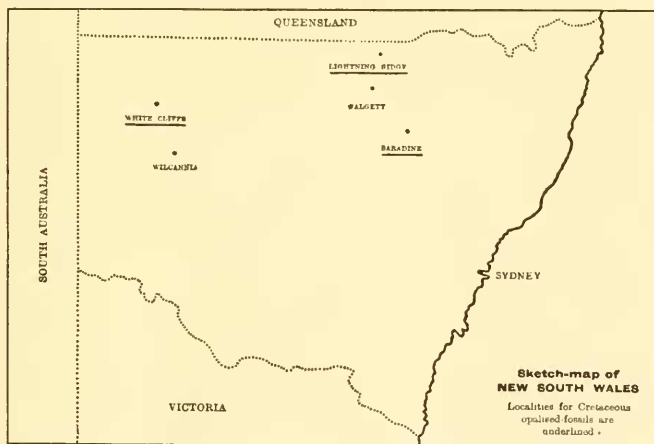
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PLATE VI.

DURING a recent visit to Australia, as a member of the British Association, I was fortunate in obtaining from a curio-merchant at Sydney a few of the rare opalized fossils of Upper Cretaceous age found in the opal-bearing strata of White Cliffs, New South Wales, some 65 miles N.N.W. of the township of Wilcannia, comprising the remains of both marine and freshwater shells, as well as a small phalangeal bone of a Plesiosaurian (*Cimoliosaurus*). These fossils



Scale: 265 miles to the inch.

now enrich the palæontological collection of the Rev. F. St. John Thackeray, M.A., F.G.S., the Vicar of Mapledurham, near Reading, to whom I am indebted for the privilege of describing them on this occasion. But, as well as considering Mr. Thackeray's specimens, the opportunity will be taken of referring to similarly opalized shells from the same beds contained in the Geological and Mineral Departments of the British Museum, which have been on exhibition for some years, bearing more or less provisional identifications, a new study of which, it is hoped, will lead to a more accurate knowledge of their relationships.

The British Museum (Geological Department) also possesses two Pelecypods of freshwater habits from the Lightning Ridge opal-field, situated in the parish of Wallangulla, county Finch, near the Queensland border, and distant about 50 miles from Walgett in

a northerly direction, which are of interest, as no determined molluscan remains have hitherto been recorded from this area. The deposits have, however, yielded Dinosaurian bones which have been referred to in literature by Dr. A. S. Woodward. Another locality in New South Wales for opalized fossils has quite recently come into prominence through the discovery of *Ceratodus* remains at Baradine, situated some 90 miles S.S.E. of Walgett, which Mr. Chapman has just described, a fact of much interest, since this is a genus of fish which still survives in Queensland rivers.

List of the recognized Cretaceous opalized fossils from New South Wales, including the new species of Pelecypoda described in the present paper.

PLANTÆ.

Araucarioxylon sp., Gürich.

CRINOIDEA.

Isocrinus australis, Moore, sp.

PELECYPODA.

Unio white-cliffsensis, n.sp.

Unio sp. indet.

Unio jaqueti, n.sp.

Cyrenopsis australiensis, n.sp.

Cyrenopsis (?) *elongata*, n.sp.

Cyrenopsis meeki } Etheridge, jun.

Cyrenopsis opallites }

Corbicula corrugata, Tate, sp.

Fissilunula clarkei, Moore, sp.

Maccoyella barklyi, Moore, sp.

Inoceramus sp.

Modiola dunlopensis } Etheridge, jun.

Modiola tatei }

Modiola sp. indet. }

Trigonia sp. cf. *moorei*, Lycett (Gürich).

Gresslya sp. cf. *gregaria*, Goldfuss (Gürich).

Teredina opalina, Gürich.

GASTROPODA.

Euspira variabilis (reflecta), Moore, sp.

Viviparus (?) *alba-scopularis*, Etheridge, jun.

CEPHALOPODA.

Belemnites canhami, Tate } *Actinocamax*, according to

Belemnites kleini, Gürich } G. C. Crick.

Ammonites.

PISCES.

Ceratodus (Metaceratodus) wollastoni, Chapman.

REPTILIA.

Cimoliosaurus leucoscopelus, Etheridge, jun.

Polyptychodon (H. Woodward's determination).

Dinosaurian remains of a Megalosaurian type (A. S. Woodward).

The evidence of these fossils, consisting of terrestrial, freshwater, and marine organisms, clearly proves the estuarine origin of the opal deposits of New South Wales, and their association with the opalized coniferous wood (*Araucarioxylon* sp. of Gürich) further accentuates this view. Although the fauna, so far as we know it, is quite endemic, yet it is of interest to point out that a somewhat similar assemblage of forms characterizes some of the estuarine deposits occurring in the Cretaceous strata of North America. For instance, the Judith River group of rocks in the Wyoming region of the United States, which are of the latest Cretaceous age, have yielded both *Corbicula* and Dinosaurian remains in association. Then, again, there are the Belly¹ River deposits of Canada (Alberta), of somewhat similar age, which contain Plesiosaurian (*Cimoliosaurus*) and Dinosaurian bones, as well as Unioniform shells, *Corbicula*, *Viviparus*, etc., and those of marine habit like *Pteria*, *Mytilus*, *Ostrea*, etc. (Whiteaves, Geol. Nat. Hist. Surv. Canada, vol. i, p. 55, 1885). The Belly River and Judith River beds are recognized as belonging to the Montana epoch (see Chamberlin & Salisbury, *Geology*, vol. iii, p. 152, 1906), which represents very high Cretaceous, or probably what may be the equivalent of the Danian of Europe. It is, therefore, possible that the opalized deposits of Australia were laid down at nearly the end of Cretaceous times. It often happens that these mineralized shells, before they reach the palæontologist, have been polished by the lapidary to intensify their opalescent characters, an operation which of course is very much to the detriment of the finer structures of the fossils, although among the specimens to be noticed are those which have escaped such treatment and in which the details of sculpture have been preserved.

I wish to record my indebtedness to Mr. Spencer for giving me facilities to examine Australian opalized shells in the Mineral Department of the British Museum, to Messrs. E. A. Smith and G. C. Crick for information on certain of the Mollusca, as also to Drs. A. S. Woodward and C. W. Andrews for suggestions in connexion with the vertebrates found in the same deposits.

BIBLIOGRAPHY.

The opal deposits of White Cliffs were first noticed by Mr. W. Anderson² in 1892, who described them as very siliceous, horizontally bedded sandstones of Upper Cretaceous age, and the probable equivalent of the Desert Sandstone of Queensland; in close proximity were vertical Silurian slates and horizontally bedded Devonian conglomerates and sandstones. Reference was also made to the original structures of the Mollusca, wood, Emericites, etc., found in the beds being replaced by opaline matter. Mr. Anderson regarded opal as a secondary product of igneous rocks, sandstones, limestones, etc., which is usually the result of deposition from opal-silica solutions percolating through the rocks.

¹ According to the latest information from Canada, this river is now to be known as the Lethbridge River.

² "Notes on the Occurrence of Opal in New South Wales": Rec. Geol. Surv. N.S.W., vol. iii, pt. i, pp. 29-32, 1892.

In the following year Mr. J. B. Jaquet¹ offered a fuller account of the deposits at White Cliffs, and similarly regarded them as Upper Cretaceous and contemporaneous with the Desert Sandstone of Queensland (an extensive formation originally described by Daintree,² who, in the absence of accurate fossiliferous evidence, wrongly considered it as part of the Kainozoic system). The opal beds were referred to as resting on Palæozoic rocks, and consisting of conglomerates and kaolin, the fossils found in them being mentioned as Mollusca, *Belemnites*, and wood. Scattered throughout the deposits were "enormous waterworn boulders" of a vitreous-looking sandstone which, when broken open, exhibited thin veins of opal as well as "impressions of characteristic Devonian Mollusca and other invertebrates". These boulders were stated to have been derived from Palæozoic conglomerates and sandstones occurring to the westward of the opal-field. It was further mentioned that "the occurrence of nodules and veins of opal, the replacement of the remains of Mollusca and other organisms by opal, and the deposition of opaline quartz in the interstices of the conglomerate belonging to this formation, and the foreign boulders of sandstone which are found in it, would seem to indicate that at some period the beds had siliceous waters running through them. The presence of hydrous silica in various forms seems characteristic of these beds wherever they have been observed".

Mr. F. G. de V. Gipps³ in 1894 referred briefly to some opalized organisms he had found at White Cliffs, which included Plesiosaurian bones, crinoid arms, and wood; and the following Mollusca determined by Mr. Etheridge, jun.: *Maccoyella reflecta*, *Tellina* sp. indet., *Modiola*, *Natica variabilis*, and *Belemnites canhami*.

During 1895 Dr. Henry Woodward⁴ exhibited at the Geological Society some "opalized Cretaceous fossils, consisting of a tooth of *Polyptychodon* [now in the Geological Department of the British Museum, R. 2614], the guard of a *Belemnitella*, and a bivalve shell, from New South Wales", and "precious opal having the form of a *Natica*"; they presumably came from White Cliffs, although no particular locality was stated in this brief announcement (see R. Etheridge, jun., Mem. Geol. Surv. N.S.W., Palæontology, No. xi, p. 6, 1902).

Interesting observations on the opalization of fossil organic remains from White Cliffs were published by Mr. Etheridge, jun.,⁵ in 1897, when describing some reptilian remains (*Cimoliosaurus*) from that locality. He referred to the occurrence in those beds of "Crinoid remains, the shells of Peleypoda and Gastropoda, portions of Belemnite guards, Sauropterygian bones, and an Ammonite wholly

¹ "On the White Cliffs Opal-field": Ann. Rep. Dept. Mines Agric. N.S.W. for 1892-3, pp. 140-2.

² "Notes on the Geology of Queensland": Quart. Journ. Geol. Soc., vol. xxviii, p. 275, 1872.

³ Trans. Australasian Inst. Min. Eng., vol. ii, pp. 70-80, 1894.

⁴ Quart. Journ. Geol. Soc., vol. li, Proc., p. iii, 1895.

⁵ "An Australian Sauropterygian (*Cimoliosaurus*) converted into Precious Opal": Rec. Australian Mus., vol. iii, No. 2, pp. 19-27, pls. v-vii, 1897.

converted into precious opal (6 inches in diameter), unfortunately since destroyed in a conflagration, but which was once in the Geological Survey Museum of New South Wales. The preservation of some of these fossils is excellent, although all are not alike in this respect, and the extent to which the opalization has at times been carried is remarkable". Considerable colour effects are visible by reflected light, Mr. Etheridge having noticed "principally blue, red, green, and yellow, with their various shades and combinations, not the least pleasing being an ever-varying degree of red and blue-tinted purple".

In the succeeding year two opalized Pelecypods from White Cliffs were described by the late Professor Ralph Tate¹ as *Lucina* (?) *bonythoni* and *Platopsis* (?) *corrugata*, both being regarded as new species and of Upper Cretaceous age. The late Professor H. G. Seeley² referred in the same year to the humerus of a Plesiosaurian from the opal-mines of White Cliffs, in which "the substance of the bone was almost entirely replaced by opal"; this specimen, it is interesting to state, is now in the Mineral Department (No. 83630) of the British Museum. Mr. G. Gürich,³ of Breslau, next published an account of some Mollusca, a vertebra of *Plesiosaurus*, and fossil wood (*Araucarioxylon* sp.) from the same opal deposits, and regarded them as of younger Jurassic age, the molluscan species being as follows:—

- Avicula barklyi*, Moore.
Trigonia sp. cf. *moorei*, Lycett.
Cyrena (?), n.sp.
Teredina opalina, Gürich.
Gresslya sp. cf. *gregaria*, Goldfuss.
Natica variabilis, Moore.
Belemnites kleini, Gürich.

The more complete account, however, of the palæontology of the White Cliffs opalized beds was that contributed by Mr. Etheridge, jun.,⁴ in 1902, which included a bibliography, as well as descriptions and figures of new and little-known species of Mollusca embracing the establishment of two new genera of Pelecypoda, viz. *Pissilunula* and *Cyrenopsis*. The list of species included the following forms:—

CRINOIDEA.

- Isocrinus australis*, Moore, sp.

PELECYPODA.

- Maccoyella barklyi*, Moore, sp.
Inoceramus sp.
Modiola dunlopensis
Modiola tatei
Modiola sp. indet.
Cyrenopsis opallites } Etheridge, jun.

¹ Trans. R. Soc. S. Australia, vol. xxii, pt. ii, pp. 77-9, text-figures, 1898.

² Quart. Journ. Geol. Soc., vol. liv, Proc., p. cvi, 1898.

³ Neues Jahrb., Beilage Band xiv, pl. xix, pp. 484-500, 1901.

⁴ Monograph of the Cretaceous Invertebrate Fauna of New South Wales (Mem. Geol. Surv. N.S.W., Palæontology, No. xi. 1902).

Cyrenopsis (?) *corrugata*, Tate, sp.

Teredina opalina, Gürich.

Fissilunula clarkei, Moore, sp.

GASTROPODA.

Pseudamaura variabilis } Moore, sp.

Pseudamaura reflecta }

Viviparus (?) *alba-scopularis*, Etheridge, jun.

CEPHALOPODA.

Belemnites canhami, Tate.

Belemnites kleini, Gürich.

In some prefatory remarks to Mr. Etheridge's memoir, Mr. E. F. Pittman introduced a detailed section of the deposits at White Cliffs, and supported their Upper Cretaceous age, which was first pronounced by Anderson, as against Gürich's view that they should be considered younger Jurassic. A comparatively new opal-field at Lightning Ridge, New South Wales, was reported upon in 1906 by Mr. J. B. Jaquet.¹ From a geological section (text-figure) accompanying the account, it is seen that the Upper Cretaceous or Desert Sandstone beds of this area consist of "white powdery siliceous rock, with opal", beneath being the Lower Cretaceous or Rolling Downs deposits, and surmounting the whole is a capping of "quartz pebble conglomerate". There is no reference to the occurrence of fossiliferous remains, although Mr. Jaquet regarded the beds as identical in their modes of structure with those at White Cliffs. The locality is famous for the much-coveted 'black opal' which is found in association with opals of ordinary character.

A new interest was given to the Lightning Ridge Beds² in 1910, when it was announced by Dr. A. S. Woodward that Dinosaurian bones had been discovered there, representing a small Megalosaurian animal now preserved in the Geological Department of the British Museum (R. 3716-18). The account stated that the specimens were opalized, and that they occurred with other bones and shells in a similar condition, their geological age being given as Upper Cretaceous.

A reference to the opalized deposits of New South Wales was made by Mr. C. A. Süßmilch³ in connexion with both White Cliffs and Lightning Ridge. At the former locality he mentioned the occurrence of shells, reptilian bones, and fragments of fossil wood, wholly or partly replaced by precious opal; he regarded the beds as of Upper Cretaceous age, the opalization being referred to as of secondary origin.

¹ "The Wallangulla Opal Field": Ann. Rep. Dept. Mines N.S.W. for 1905, 1906, pp. 68-9.

² "On Remains of a Megalosaurian Dinosaur from New South Wales": 79th Rep. Brit. Assoc. for 1909, 1910, pp. 482-3.

³ *An Introduction to the Geology of New South Wales* [Sydney], 1911, p. 125 (with coloured geological map).

Finally, Mr. F. Chapman,¹ Palæontologist of the National Museum at Melbourne, has quite recently described an opalized tooth of *Ceratodus* from the Upper Cretaceous opal deposits of Baradine, some 90 miles S.S.E. of Walgett, New South Wales, and has determined it under a new sub-genus and species as *Ceratodus (Metaceratodus) wollastoni*. It is of interest to state that *Ceratodus*, although chiefly characteristic of Trias and Jurassic times, has been recognized by E. W. Cope in the Fort Union Beds of Montana, United States (Proc. Acad. Nat. Sci. Philadelphia, 1876, pp. 259-60), which are regarded as uppermost Cretaceous or oldest Eocene, as well as in the later Cretaceous deposits of Patagonia, by Ameghino. Dr. A. S. Woodward has further recorded the occurrence of *Ceratodus* and a Dinosaurian in the Lower Jurassic rocks of Gippsland, Victoria, Australia (Ann. Mag. Nat. Hist., ser. VII, vol. xviii, pl. i, pp. 1-3, 1906).

AN ACCOUNT OF THE OPALIZED MOLLUSCA CONTAINED IN THE COLLECTIONS OF THE BRITISH MUSEUM AND THE REV. F. ST. J. THACKERAY.

PELECYPODA.

Fam. CYPRINIDÆ.

Fissilunula clarkei, Moore, sp.

Cytherca clarkei, Moore, Quart. Journ. Geol. Soc., vol. xxvi, p. 250, pl. xiii, fig. 1, 1870.

Cyprina expansa, Etheridge, Quart. Journ. Geol. Soc., vol. xxviii, p. 338, pl. xix, fig. 1, 1872.

Cytherea clarkei (= *Cyprina expansa*), Tate, 1st Rep. Australasian Assoc., 1888-9, p. 230.

Cyprina clarkei, Etheridge, jun.: Jack & Etheridge, jun., Geology and Palæontology of Queensland, 1892, pp. 474, 568, pl. xxvii, fig. 9; ? pl. xxvi, figs. 18, 19; ? pl. xxvii, figs. 10, 11.

Fissilunula clarkei, Etheridge, jun., Mem. Geol. Surv. N.S.W., Palæontology, No. xi, pp. 36-7, pl. vi, fig. 3; pl. ix, fig. 1; pl. x, figs. 1, 2; pl. xi, figs. 1, 2; 1902.

Description (original).—Shell large, thick, rather compressed, transversely ovate, inequilateral, moderately convex; umbones flattened, incurved over a large and rounded lunule; anterior and posterior ends and dorsal margin rounded; surface of the shell with broad irregular transverse bands of growth.

Remarks.—The specimen referred to this species has parts of both valves preserved in the closed condition, so that no internal characters are exposed, besides which the umbones are, unfortunately, absent.

¹ "On a new species of *Ceratodus* from the Cretaceous of New South Wales": Proc. Roy. Soc. Victoria, n.s., vol. xxvii, pp. 25-7, pl. v, 1914. The genus *Ceratodus* was reported by Krefft as occurring with *Diprotodon* remains in the Alluvial deposits of Queensland (*Nature*, vol. ix, p. 293, 1874), being regarded as an extinct form under the name of *C. palmeri*, a determination subsequently set aside by C. W. De Vis, who recognized its identity with the recent *Ceratodus forsteri* of Queensland rivers (Proc. Roy. Soc. Queensland, vol. i, p. 40, 1884).

It is of small and very medium size when compared with the more adult forms from Queensland, which sometimes reach 9 inches in length: the valves are well inflated and covered with wide and rounded growth bands bearing intervening concentric striations; the posterior region is subangulate and furnished with strongly oblique lines of growth, whereas anteriorly the valves are slightly compressed and narrow in the direction of the outer margin; the lunular excavation appears to be rather shallower than usual, probably on account of the absence of the umbones.

Dimensions (approximate).—Length 60, height 50, diameter 35 mm.



A



B

FISSILUNULA CLARKEI (Moore).

A = Left lateral view of specimen.

B = Ventral aspect of same, showing well-inflated valves.

Loc. White Cliffs. British Museum (Geol. Dept., L. 21274).

Moore's original description of the Queensland shell was based upon very imperfect material, but from the later studies of Mr. Etheridge, jun., of better preserved examples the real affinities of the species came to be more accurately known. From a delineation of the hinge-characters and other important internal structures, that author was able to prove fairly close relationships to *Isocardia*, and thus he made the species the type of his new genus *Fissilunula*. The present fossil compares favourably with a partially testiferous cast originally collected by Mr. H. Y. L. Brown from the Cretaceous region north of Lake Eyre, South Australia, and which he presented to the British Museum (Geol. Dept., L. 9682), where it was determined years ago by Mr. Etheridge, jun., as Moore's *Cytherea clarkei*. That specimen, however, is rather more compressed, but allowing for certain

variations which exist in the species, it would appear reasonable to regard the example from White Cliffs as belonging to the same form.

Locality.—White Cliffs, New South Wales.

Collection.—British Museum (Geol. Dept., L. 21274).

Distribution.—Lower Cretaceous: New South Wales, Queensland, and South Australia. Upper Cretaceous: Queensland and South Australia (Lake Eyre region).

Fam. PTERIIDÆ (= Aviculidæ).

MACCOYELLA BARKLYI, Moore, sp. Pl. VI, Fig. 19.

Avicula barklyi, Moore, Quart. Journ. Geol. Soc., vol. xxvi, p. 245, pl. xi, figs. 1, 2, 1870.

Avicula alata, Etheridge, Quart. Journ. Geol. Soc., vol. xxviii, p. 342, pl. xx, fig. 8, 1872.

Monotis barklyi, Tate, Trans. Roy. Soc. South Australia, vol. iii, p. 179, 1880.

Maccoyella barklyi, Etheridge, jun.: Jack & Etheridge, Geology and Palæontology of Queensland, 1892, p. 455, pl. xxii, figs. 1-5; pl. xlii, figs. 4-6; pl. xxiii, figs. 1-2; Mem. Geol. Surv. N.S.W., Palæontology, 1902, No. xi, p. 17, pl. ii, figs. 3-5; pl. iii, figs. 4, 5; pl. iv, figs. 3, 4.

Description (original).—Shell slightly inequilateral, orbicular, large valve convex, small valve flattened, umbones prominent; auricles rather small, nearly equal. The large valve slightly produced posteriorly and ornamented with 24 radiating costæ, which are more raised and appear spinous on the posterior margin. The small valve slightly convex with a very distinct ornamentation from the larger, the costæ being much finer, and about 44 in number. The costæ are decussated by numerous regular concentric lines of growth, which, when they meet, give them a nodulated aspect. The lines of growth have been reflected or folded over the anterior auricle and side, which gives the shell a very peculiar appearance. The small valve possesses a large and deep groove for the passage of a byssus. The punctate structure of the Aviculidæ may be clearly distinguished, by aid of the lens, in this species.

Remarks.—The specimen referred to this species exhibits an external view of a left valve which is so attached to the matrix that all internal characters are concealed. It is of medium size, slightly convex, with an umbo well above the dorsal line; the margins are fractured and imperfect, especially posteriorly, while the ventral border is rounded. Although much eroded the surface has still preserved some thirteen equidistant, primary, radial costæ, an obscure secondary rib dividing equally the intercostal spaces being occasionally present, and seen only in the later development of the shell, and which is not observable on the umbonal region. Numerous close, concentric striations form part of the ornament of the valve, and where they cross the radial costæ minute nodulations are produced.

Dimensions (approximate).—Length 40, height 38 mm.

We are indebted to Mr. Etheridge, jun., for our later knowledge of this species, which he made the type of his genus *Maccoyella* (Jack

and Etheridge, *The Geology and Palaeontology of Queensland*, 1892, p. 451), including therein further species from the Queensland Cretaceous, all of which were described by Moore under the genus *Avicula*. It was pointed out that the chief peculiarities of *Maccoyella* were connected with the hinge-structure of both valves, which widely differed from those characterizing *Avicula*; but, unfortunately, the specimen from White Cliffs is too much buried in matrix to allow of the comparison of internal characters; from external features, however, it may be said to resemble the published figures of this shell, especially *Avicula alata* of Etheridge, sen., from the Desert Sandstone of Queensland, recognized as a synonym of the present species, and a kaolinized cast of a valve from White Cliffs figured by Mr. Etheridge, jun. (pl. iv, fig. 4), in his last account of this species.

Locality.—White Cliffs, New South Wales.

Collection.—British Museum (Geol. Dept., L. 21272).

Distribution.—Lower Cretaceous: South Australia (Peak Creek and Lake Eyre district); Queensland; New South Wales. Upper Cretaceous: Queensland (Maryborough); New South Wales (White Cliffs).

Fam. CYRENIDÆ.

CYRENOPSIS MEEKI (Etheridge, jun.). Pl. VI, Figs. 13, 14.

Maetra meeki and *Unicardium* (?) *meeki*, Etheridge, jun.: Jack and Etheridge, jun., *Geology and Palaeontology of Queensland*, 1892, pp. 472-3, pl. xxvii, figs. 2, 3; pl. xxvi, figs. 13-15.

Cyrena meeki and *Corbicula* (?) *meeki*, Etheridge, jun., *Mem. Roy. Soc. S. Australia*, vol. ii, pt. i, pp. 30-1, pl. vi, figs. 8-13, 1902.

Cyrenopsis.—Type *Maetra* (vel *Corbicula*) *meeki*, Etheridge, jun., *Mem. Geol. Surv. N.S.W., Palaeontology*, No. xi, p. 28, 1902.

Description (author's diagnosis of 1902).—Shell obtusely triangular, somewhat cuneiform, and posteriorly produced, moderately convex. Cardinal margins considerably arched, the anterior shorter than the posterior; ventral margins rounded throughout, curving rapidly upwards anteriorly, but less curved posteriorly; anterior margins well rounded; the posterior-ventral extremities produced, but obtusely rounded. Umbones moderately large, obtuse and contiguous; anterior and posterior diagonal slopes obtusely rounded, posterior area ill-defined, ligament short and strong. A large, robust, projecting, triangular, submedian cardinal tooth in each valve; anterior and posterior lateral teeth lamellar and projecting; sculpture of concentric lamellæ, of slightly variable width, and on the anterior slopes gathered in bundles; the lamellæ bear numerous very fine and regular concentric lines.

Remarks.—There is only one specimen in the British Museum which may be referred to this species. Its valves, in the closed condition, are, however, fragmentary and without umbones, but its cuneiformity, triangular outline, rounded ventral margins, produced posterior margins, and abruptly truncated area, all agree with Mr. Etheridge's figures, especially 13 and 15 of plate xxvi of the Queensland memoir. Some slight additions may be made to the

ornamentation of the species as exhibited in this specimen. The sculpture is seen to consist of bold concentric depressed ridges and broad shallow sulcations covered with fine concentric lineations, but crossing them are numerous short, microscopical, vertical striations, as well as occasional longer and filamentous lines similarly directed, mostly confined to the ventral region, such as may be seen on the valves of both fossil and recent freshwater Pelecypoda, being sometimes present in *Corbicula cuneiformis* of J. Sowerby, from the older Eocene deposits of England and Europe, as also in further fossil species of that genus; it is besides seen on Unioniform shells, for which examples of *Unio tumidus* of Retzius in the Geological Department of the British Museum (L. 10032) may be quoted, which were obtained from the Post-Pliocene deposits of the Lea Marshes near London; and the character is also apparent in *Anodonta becklesi*, which I described some years since before this Society (Proc. Malac. Soc., vol. ix, pp. 114-17, pl. i, 1910) from the English Wealden formation.

Dimensions.—Length 29, height 26 (approx.), diameter 15 mm.

This species forms the type of *Cyrenopsis*, Etheridge, jun., being at first regarded as a doubtful *Unicardium* and afterwards as an example of *Maetra*. A more complete study of the dentition enabled the author to see its close connexion with Cyreniform shells like *Corbicula*, from which it differed, however, in the possession of a triangular, submedian, cardinal tooth in each valve, making two instead of three teeth for both valves as in that genus.

Locality.—Lightning Ridge, New South Wales.

Collection.—British Museum (Geol. Dept., L. 21832).

Distribution.—Lower Cretaceous of Queensland (Walsh River) and South Australia (Lake Eyre Basin).

CYRENOPSIS OPALLITES, Etheridge, jun. Pl. VI, Figs. 11, 12.

? *Cyrena* (?), n.sp., Gürich, Neues Jahrb., Beilage Band xiv, p. 486, pl. xix, figs. 5, 6, 1901.

Cyrenopsis opallites, Etheridge, jun.: Mem. Geol. Surv. New South Wales, Palæontology, No. xi, p. 29, pl. v, figs. 12-17, 1902.

Description (original).—Shell ovate, moderately inflated; cardinal margins arched, ventral margins well rounded; anterior ends somewhat flattened, with rounded margins; posterior ends slightly produced or nasute, the dorsal posterior margins straight and oblique, the ventral rounded; posterior slopes slightly flattened, narrow, and generally inconspicuous; umbones depressed, escutcheon long, deep, and narrow; ligament short. Articulus arched, longer on the posterior than the anterior; anterior cardinal of the left valve triangular, projecting, and slightly oblique, posterior cardinal of the same valve laminar; anterior lateral slightly curved, short, posterior lateral long, distant, and straight. Central upper cardinal of the right valve laminar and almost marginal, lower cardinal laminar and oblique; anterior lateral short and curved, posterior lateral long, distant, and straight. Adductor impressions and pallial lines very faint. Sculpture of concentric laminæ, with faint coincident lines.

Remarks.—There are two excellent examples of this species in the British Museum with the valves in the closed position, and therefore not exhibiting internal characters. They are of nearly orbicular contour, and would represent the type of the species as figured and described by Etheridge. The valves exhibit a moderate convexity over the umbonal region, but afterwards considerable compression; they are furnished with a fairly deep lanceolate escutcheon and a short ligament, while beneath the umbones in front is a slightly excavated area, although possessing no true circumscribed lunule. The ornamentation consists of more or less equidistant, flattened growth-bands which are covered with closely arranged, thread-like, concentric striations which are sometimes of slightly irregular design, especially near the ventral margin.

		<i>Type</i> (from largest figure). <i>New examples.</i>	
<i>Dimensions.</i>	Length . . .	34	32 mm.
	Height . . .	31	30 mm.
	Diameter . . .	20	15 mm.

The specimen figured by Gürich, showing the dentition, which Mr. Etheridge, jun., includes under his species *opallites*, is of far larger dimensions than those mentioned above, and although no exact measurements can be made on account of the fragmentary state of the margins, it probably was nearly double the size of the largest form represented by Mr. Etheridge's figures; I have therefore queried its inclusion in this species.

Locality.—White Cliffs, New South Wales.

Collections.—British Museum (Geol. Dept., L. 21273; Mineral Dept., 80065).

Distribution.—Upper Cretaceous: White Cliffs, New South Wales.

CYRENOPSIS AUSTRALIENSIS, n.sp. Pl. VI, Figs. 9, 10.

Description.—Shell ovate, subtriangular, height less than length, umbones anterior; posterior region elongate, obliquely rounded at margin, with narrow lanceolate escutcheon bearing short ligament; anterior short, slightly excavated beneath the umbones; ventral margins round, and with rounded extremities; valves moderately convex umbonally, afterwards compressed; ornamentation consists of equidistant, concentric, periodical growth-bands furnished with fine and closely arranged concentric striations.

Dimensions (with united valves).—Length 33, height 24, diameter 11 mm.

Remarks.—The example described is the largest of three specimens, each of which is in good preservation, although no interiors are seen, as the valves are united and closed. The more or less triangulate and suboval contour, together with its anteriorly placed umbones, will suffice to separate this form from *C. meeki*, with which it is otherwise closely related. Among the specimens mentioned is one that has been highly polished by the lapidary, and is associated on a small piece of ferruginously tinted sandstone, with an example of *Euspira variabilis*.

Locality.—White Cliffs, New South Wales.

Collections.—British Museum (Mineral Dept. 1896⁷₇; Geol. Dept., G. 19603).

CYRENOPSIS(?) ELONGATA, n.sp. Pl. VI, Figs. 17, 18.

Description.—Shell thick, robust, subtrigonal, oval, length nearly $1\frac{1}{2}$ times the height, valves compresso-convex; umbones anterior, incurved; posterior region elongate, sloping, probably subangulate, anterior extremities rounded, short, ventral margins elongately curved; sculpture consisting of rather coarse, concentric, elevated, rounded growth-periods with fine concentric interlineations, crossing which are a series of short, equidistant, raised, filiform, vertical striations.

Dimensions (closed valves).—Length 32, height 24, diameter 15 mm.

Remarks.—The shell of this specimen has been partially removed by fracture from the dorsal region, especially beneath the umbones, and posteriorly where the areal surface within the margins is quite lost. Otherwise it consists of a pair of valves in the closed condition, the left lateral surface showing a well-arched umbonal region, and the surface exhibiting interesting details of sculpture. The growth-bands are more or less raised and feebly convex, while the general surface is covered with fine concentric striations, except where erosion can be traced, when such markings have become obliterated. The short vertical striations, observable in the ventral region more particularly, are of filiform character, and like a similar structure noticed previously in *Cyrenopsis meeki*, Etheridge, jun.

I have no doubt at all as to the freshwater origin of this shell, and chiefly from the peculiar character of the ornament, which indicates a slight uncertainty or irregularity in the design of the concentric lineations, a similar phenomenon existing in most Pelecypod shells of the same habit, and in this way differing from marine forms, which generally show a greater decision in their sculpture markings. As no dental characters are preserved, this shell is associated provisionally with the genus *Cyrenopsis*; it appears to differ chiefly from other species in possessing a more elongately oval contour.

Locality.—White Cliffs, New South Wales.

Collection.—Rev. F. St. J. Thackeray.

CORBICULA CORRUGATA, Tate, sp. Pl. VI, Figs. 15, 16.

Platopsis (?) *corrugata*, Tate, Trans. Roy. Soc. S. Australia, vol. xxii, p. 79, text-figures, 1898.

Cyrenopsis (?) *corrugata*, Etheridge, jun., Mem. Geol. Surv. New South Wales, Palæontology, No. xi, p. 30, 1902.

Description (original).—Shell transversely triangular, somewhat cuneiform, convexedly depressed. Umbones large, obtuse, antemedian; lunule ill-defined. The dorsal slopes straight, inclined at an angle of 95° , the posterior considerably the longer; post-ventral extremity roundly pointed, the ventral margin nearly straight to beyond the middle line, thence curving rapidly upwards to form the well-rounded anterior extremity. The post-dorsal line is bounded by

a narrow declinous lanceolate area, and delimited on its inner aspect by an ill-defined obtuse ridge extending from the umbo to the post-ventral extremity. The inner margin of the valves is smooth at post-ventral extremity. The ornamentation consists of subacute concentric undulations of variable strength, and at variable distances, separated by shallow concave spaces wider than the ridges; coincident with the undulations are widely separated linear growth-lines; the concentric undulations are continued beyond the post-umbonal ridge as close-set growth-lines.

Remarks.—There is an excellent specimen to represent this species with united valves in situ and possessing complete margins, rather inflated and obtuse umbones, and straight ventral borders with rounded extremities. The triangularity of the valves is also well expressed, a shape considerably aided by the almost straight dorsal slopes of which the posterior is much the longest. In the lanceolate escutcheon-area reposes a short, thick ligament, and beneath the umbones in front it is only very slightly excavated. The ornamentation exhibits equidistant concentric bands of growth, with raised margins, and covered with extremely fine, close, concentric striations. No external characters are exposed. *Dimensions (with united valves)*: length 25, height 20, diameter 10 mm.

This species was originally regarded as marine, and doubtfully associated with *Platopsis* of Whitfield, from the Syrian Cretaceous, being thought to have possible affinities with *Astarte*; subsequently Mr. Etheridge, jun., considered it a probable form of his genus *Cyrenopsis*, although without knowledge of the dentition, as the type showed no internal characters. My opinion, however, is that the triangularity of the shell, in addition to the other external characters, is more in favour of its being regarded as a *Corbicula* than any other genus, and therefore, until further evidence is forthcoming, it is proposed to include the species under that genus.

Locality.—White Cliffs, New South Wales.

Collection.—British Museum (Mineral Dept. 76806).

Distribution.—Upper Cretaceous: New South Wales (White Cliffs).

Fam. UNIONIDÆ.

UNIO JAQUETI, n.sp. Pl. VI, Figs. 2-6.

Description.—Shell elongately oval, narrow; dorsal margin slightly sloping to posterior extremity; dorsal and ventral borders subparallel; umbones anterior, eroded; valves compresso-convex; posterior region produced, and slightly narrowing at end, anterior and ventral borders rounded; sculpture exhibiting concentric growth-lines, crossed by numerous, closely set, fine radial striations.

		<i>Lightning Ridge.</i>	<i>White Cliffs.</i>
<i>Dimensions (with closed valves).</i>	Length . . .	42	(about) 53 mm.
	Height . . .	20	22 mm.
	Diameter . . .	12	15 mm.

Remarks.—This species is represented by two specimens of somewhat imperfect condition, but their rarity as opalized Australian

fossils makes them important for reference. The more complete, so far as contour is concerned, and which was found at Lightning Ridge, exhibits both valves in the closed state, the margins of which are generally well defined, while the anteriorly situated summit region is very depressed, the umbones having been completely eroded away, the postero-dorsal characters being also without proper definition. The shell-structure is only very partially preserved, although sufficient remains to show the presence of concentric growth-lines and some obscure microscopical radial striations. The second example is from White Cliffs, also with closed valves, and is larger than the previous form. In this the umbonal regions have disappeared through erosion, and a fractured posterior end of the specimen prevents an exact knowledge of its original length, although this seems to have been about 53 mm. The dorsal view, however, exhibits a part of what would have been a fairly long lanceolate escutcheon with sharply angulate lateral borders, enclosing a well-rounded, lengthy ligament, bearing annulations of growth, and furnished with tapering extremities, the concentric growth-lines forming a fairly sharp angle where they meet the margins of the escutcheon. The radial striations are either absent or only very obscurely traceable, erosion having probably obliterated these finer details of sculpture.

I would wish to associate with this shell the name of Mr. J. B. Jaquet, who was the first geologist to describe the Lightning Ridge opal deposits, and who previously had furnished important details in connexion with the constitution of the beds at White Cliffs.

Localities.—Lightning Ridge and White Cliffs, New South Wales.

Collections.—British Museum (Geol. Dept., L. 21833); Rev. F. St. J. Thackeray.

UNIO WHITE-CLIFFSENSIS, n.sp. Pl. VI, Figs. 7, 8.

Description.—Shell of small size, with moderately inflated valves, length about $1\frac{1}{2}$ times the height; umbonal regions anterior, coarsely rugose or marked with strong, widely V-shaped costæ; anterior margin rounded, posterior side with an elongate, abrupt, oblique, and narrow, angulate, ridged area, in front of which the valve is slightly excavated. Sculpture beyond the V-shaped costal rugosities of the umbonal area consists of periodical growth-divisions, and numerous, closely set, microscopical concentric striations, which at the posterior ridge become angulate, and take an upwardly oblique direction on the surface of the posterior area.

Dimensions (with closed valves).—Length 22, height 15, diameter 10 mm.

Remarks.—This specimen exhibits a pair of closed valves, which, however, are not quite in situ, having slightly shifted from each other during the process of fossilization. It is a well-marked form, with all the characters referred to properly defined; the umbones themselves are not present, but the rugose umbonal regions are quite definite and characteristic of Unioniform shells.

Locality.—White Cliffs, New South Wales.

Collection.—Rev. F. St. J. Thackeray.

UNIO sp. indet. Pl. VI, Fig. 1.

Description.—Shell of oblong, oval contour, compressed, moderately and uniformly convex; dorsal margin elongate, declining slightly to the narrower posterior end, ventral margin nearly straight; umbonal region very anterior, extremities more or less rounded; sculpture consisting of fine concentric growth-lines with no evidence of radial striations.

Dimensions (right valve).—Length 60, height 30, diameter 14 mm.

Remarks.—Only a small fragment of testiferous structure is obscurely preserved near the posterior end of this specimen, otherwise the lapidary, in developing its opalescent qualities, has destroyed all the original details of structure. The contour and general compression, however, may probably be relied on, although the marginal boundaries are a little uncertain. The shape appears to bear some resemblance to forms of *Unio* found in the Judith River Beds (= uppermost Cretaceous) of the United States, such as are figured in Meek's "Invertebrate Cretaceous and Tertiary Fossils of the Upper Missouri Country": United States Geol. Surv. Terr., vol. ix, pl. xli, 1876 (i.e. *Unio danae*, Meek & Hayden), but without the radial striations that ornament the American shells. The specimen represents an external view of a right valve with the umbonal area wanting, the whole of the interior being filled with a moderately soft kaolinized sandy matrix.

Locality.—White Cliffs, New South Wales.

Collection.—Rev. F. St. John Thackeray.

GASTROPODA.

Fam. NATICIDÆ.

EUSPIRA VARIABILIS (Moore). Pl. VI, Figs. 20-3.

Natica variabilis and *Delphinula reflecta*, Moore, Quart. Journ. Geol. Soc., vol. xxvi, p. 256, pl. x, figs. 15, 21, 1870.

Natica lineata, Etheridge, Quart. Journ. Geol. Soc., vol. xxviii, p. 342, pl. xxi, fig. 1, 1872.

Delphinula (?) *reflecta*, Etheridge, jun.: Jack & Etheridge, jun., Geology and Palæontology of Queensland, 1892, p. 485, pl. xxix, fig. 12; p. 573, pl. xxxi, figs. 2, 3.

Natica variabilis, Gürich. Neues Jahrb., Beilage Band xiv, p. 489, pl. xix, fig. 7, 1901; Etheridge, jun., Mem. Roy. Soc. S. Australia, vol. ii, pt. i, p. 42, pl. vi, figs. 15-17, 1902.

Pseudamaura reflecta and *Pseudamaura variabilis*, Etheridge, jun., Mem. Geol. Survey N.S.W., Palæontology, 1902, No. xi, pp. 40-3, pl. ii, figs. 9-12, 13-16.

Descriptions (original): Of *variabilis*. Shell very thick, broader than high; spire of 3-4 volutions, somewhat depressed; body-whorl increasing rapidly, and extended; aperture ovate; umbilicus small.

Of *reflecta*. Shell rather small, turbinated; whorls 3-4, spire slightly elevated; volutions separated by an encircling sinus; body-whorl much increased; aperture circular, with a thick reflected lip.

Remarks.—Mr. Etheridge, jun., has carefully studied the merits of Moore's imperfectly defined species, *Natica variabilis* and *Delphinula reflecta*, and has acknowledged the difficulty of separating them on account of the similarity of their characters. He has alluded to the presence of an ovate aperture in the first-named, and one of rounder contour in the other, as of some importance, although an unfortunate slip in the text informs us that it is "ovate" in both. Apart from this, however, Mr. Etheridge's figures do not assist us as to the actual roundness of the aperture in the species *reflecta*, in which case it is thought that the apertures for both would be better diagnosed as more or less ovate, and consequently both species might with advantage be united, more especially as the remaining characters are very similar in each; it is, therefore, suggested to retain *variabilis*.

Well-preserved specimens are seen to be ornamented with fairly strong growth-lines, crossed by microscopically small, close, and spiral striations; one specimen, however, in the British Museum (Mineral Dept.) exhibits a series of thick, equidistant, vertical costæ on the penultimate whorl, which is a somewhat unusual structure, having a resemblance to what is occasionally seen on the spire of *Gyrodes pansus* from the Indian Cretaceous as figured by Stoliczka,¹ who regarded such markings as raised striæ of growth, while Mr. Etheridge, jun., has noted and figured the same ornament in an example of the species from the Lower Cretaceous deposits of South Australia, which, like the present specimen, has the general characters of *Natica variabilis* (see pl. vi, fig. 17, Mem. Roy. Soc. S. Australia).

Another difficulty presents itself as to the proper genus with which to associate this species. Mr. Etheridge, jun., recognized it as belonging to Fischer's *Pseudamaura*, of which the type is *Natica bulbiformis* of J. de C. Sowerby from the Austrian (Gosau) Cretaceous; but that seems an unsatisfactory determination, because the Austrian fossil has a much more elongate and tabulate spire, as well as possessing an extensive callus to the inner lip, and is besides without any indication of an umbilical opening. The Australian shell much more nearly approximates in spiral structure to the Cretaceous *Gyrodes*, although removed from it by the absence of a wide basal excavation which characterizes that genus. It is now suggested that Agassiz's *Euspira*² should include this species, which was founded on *Natica glaucinoides* of J. Sowerby from British Lower Eocene rocks, and which seems to embrace, in a more or less modified manner, the chief characters of the shell in question.

Locality.—White Cliffs, New South Wales.

Collections.—British Museum (Geol. Dept., G. 19602-3; Mineral Dept., $\frac{57}{1907}$, $\frac{69}{1908}$); Rev. F. St. J. Thackeray.

Distribution.—Lower Cretaceous: South Australia; Queensland. Upper Cretaceous: White Cliffs, New South Wales.

¹ "Cretaceous Fauna of Southern India (Gastropoda)": Mem. Geol. Surv. India, Palæontologia Indica, vol. ii, pl. xxii, fig. 9a, 1868.

² Desor & Agassiz, Conchyliologie Minéralogique de la Grande Bretagne par James Sowerby, traduit de l'Anglais, p. 15, 1838.

CEPHALOPODA.

Fam. BELEMNITIDÆ.

ACTINOCAMAX spp.

Belemnitifform guards are of rather frequent occurrence in these opalized beds of Australia (White Cliffs), having been first referred to by Dr. Henry Woodward as belonging to the genus *Belemnitella*, and by later authors as *Belemnites*, under the species *canhami*, Tate, and *kleini*, Gürich. Mr. G. C. Crick, of the British Museum, who has examined the evidence, is of opinion that such remains would be more accurately determined as *Actinocamax*, and that without question they denote an Upper Cretaceous age.

Locality.—White Cliffs, New South Wales.

Collections.—British Museum (Geol. Dept., C. 12086-7; Mineral Dept., $\frac{5}{1907}$); Rev. F. St. J. Thackeray.

EXPLANATION OF PLATE VI.

The figures are of the natural size with the exception of 4, 14, and 23, which represent magnifications of sculpture.

FIG.

UNIO sp. indet.

1. An imperfect right valve with polished surface, exhibiting faint traces of concentric growth-lines in the posterior region.

Loc. White Cliffs. Rev. F. St. J. Thackeray Coll.

UNIO JAQUETI, n.sp.

2. Left lateral aspect.
3. Ventral view of same, showing the shallow, depressed valves.
4. Sculpture magnified, consisting of closely arranged radial striations.
5. Left lateral view of another specimen, imperfect posteriorly.
6. Dorsal view of same, exhibiting eroded umbones and a prominent ligament with annulations of growth.

Loc. White Cliffs. Rev. F. St. J. Thackeray Coll.

UNIO WHITE-CLIFFSENSIS, n.sp.

7. Left lateral view, showing the umbonal V-shaped rugosities.
8. Right lateral aspect of same, in which the posteriorly ridged area is seen.

Loc. White Cliffs. Rev. F. St. J. Thackeray Coll.

CYRENOPSIS AUSTRALIENSIS, n.sp.

9. Left lateral view of a slightly fractured example displaying the periodical growth-bands.
10. Dorsal aspect of same, showing shallow valves and a short ligament.

Loc. White Cliffs. British Museum (Min. Dept., $\frac{577}{1907}$).

CYRENOPSIS OPALLITES, Etheridge, jun.

11. Right lateral aspect, showing a nearly orbicular contour.
12. Dorsal position of same, exhibiting considerable umbonal convexity and elongate escutcheon.

Loc. White Cliffs. British Museum (Min. Dept., 80065).

CYRENOPSIS MEEKI, Etheridge, jun.

13. Left lateral view, showing a triangularity of contour.
14. Sculpture details magnified, in which the short and longer radial striations are seen crossing the concentric growth-lines.

Loc. Lightning Ridge. British Museum (Geol. Dept., L. 21832).

